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Washington, D. C. 20024

date: June 30, 1971

to: Distribution

from: D. B. Wood

B71 06059

subject: Space Shuttle Sortie Mode
Presentation - Case 236

ABSTRACT

The Space Shuttle, operating in the sortie mode, has the potential to provide an entirely new way of performing scientific research and engineering research and development in space. The sortie mode is defined, and then discussed in the context of a "good" research program. The sortie mode described is having the following key features:

- Economical
- Many Flight Opportunities
- Flexible
- Wide Participation

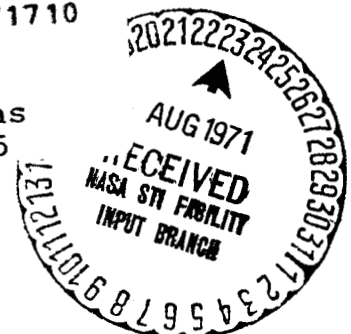
In order to provide these features, the Shuttle must conform to certain operational and design requirements, which consider the sortie mode as a major use of the Shuttle. Among these requirements is the capability to sustain seven to ten scientists or engineers on-orbit for two to four weeks.

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MEMORANDUM FOR FILE

In support of the NASA Experiments Management Working Group, headed by L. Scherer/MAL, a presentation was given on May 4 by the author. It is felt that the Space Shuttle experiments should be managed quite differently than are the Skylab experiments. One of the greatest potentialities of the Shuttle is its operation in the "sortie mode". This type of operation, patterned after NASA's highly successful airborne research program, is entirely new to space research.

The following text was prepared in support of the oral presentation.

I. INTRODUCTION

Herein I address the potential of the Space Shuttle sortie mode to scientific research and to engineering research and development in space. My vantage point is that of a scientist, but most of the arguments based on scientific research apply equally well to engineering R&D.

Two terms which must be defined are "sortie mode" and "good research".

Sortie Mode: This is a mode of Shuttle operation wherein disciplinary investigators (scientists, graduate students, engineers, technicians) go into space with their own apparatus. The experiments which they conduct are economical; due primarily to their personal presence, maximum use of off-the-shelf and reusable equipment, and minimal documentation and testing requirements. The investigations which they carry out are flexible, because the Shuttle can achieve a variety of orbits and because the investigators are there with their equipment able to respond in real time to unexpected results.



Good Research: For research to be productive - at the forefront of progress - it must have three essential elements: it must be timely; it must be flexible; it must be competitive. The same elements define good engineering development.

Historically, our space research has not contained the above elements. Up until now, our research has been productive because it has been in a totally new environment; it has been timely because it has been "first". Only sounding rockets, balloons, and airplanes have provided research which has been fairly competitive and has had relatively short lead times.

The sortie mode has the potential to provide a major new way of doing space research, and we should be able to perform scientific research and engineering research and development which is timely, flexible and competitive.

II. FEATURES OF SORTIE MODE

The Shuttle can provide an ideal platform for good research in space, since it has the potential for the following features:

- Economical
- Many Flight Opportunities
- Flexible
- Wide Participation

I will discuss these below.

Economical: It is important that the "sortie module", which carries the investigators and their equipment in the Shuttle payload bay, be as simple as possible. It should not be erectable and should not be capable of existing independently of the Shuttle. Because, especially in the first five or more years of all-up Shuttle operation, the sortie mode will be extremely important (accounting for a large percentage of the flights), the sortie module should not be a later development, but either part of the Shuttle development or a concurrent development.



The sortie module can provide further economies and safety for scientific research and engineering development by having standard on-board equipment (recorders, pulse height analyzers, computer) and standard interfaces (airlocks, power, data, cooling).

Experimentation can be low cost because, in addition to the above economies, the apparatus can be borrowed, or be reusable, and have a short development time. Bread-board apparatus can be flown.

Many Flight Opportunities: The frequency of Shuttle flights should permit experiments to be flown on rather short notice. It will permit the reflight of experiments; because they have failed or because they have been so successful. It should permit a much more reliably-scheduled flight date, which is particularly necessary for some biological experiments.

Flexible: The investigator, being on-board with his relatively conventional apparatus (that is, not highly miniaturized and automated), can alter it or its operation during flight. A sortie flight is capable of accommodating a wide variety of investigations by scientists, engineers and technicians from many disciplines. Spacecraft attitude should be freely alterable, and a variety of different orbits should be obtainable at launch.

Wide Participation: Because of the above traits (economy, opportunity and flexibility), there will be a large number of participants. Low cost experimentation will permit the support of a large number of research teams, providing the competition that results in keen research and development. Once the Shuttle has proven itself to be capable of this kind of operation, the demand should be very great. I imagine the number of sortie flights will be limited not by demand or useful work to be accomplished, but only by the money available to fund so many flights. A successful sortie mode means that man in space operating productively becomes a common reality.

III. SHUTTLE ATTRIBUTES ENVISIONED - DESIGN CONSTRAINTS

I consider the following three attributes key to the sortie mode definition, so they are reiterated here:

- A research crew consisting of scientists, engineers and technicians, who will operate their own apparatus in space.



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- Reduced documentation and reliability requirements on experiments. Getting an experiment on-board should be simple and straightforward, within safety constraints.

- Operational flexibility, which is provided through a number of operational and hardware specifications in the Shuttle design.

These operational hardware design specifications are described below. Obviously there are trade-offs to be made, and all missions cannot provide all features. However, failure to provide for very many of these will seriously jeopardize the sortie-mode potential of the Shuttle to accomplish good research and development.

- Local Vertical Stabilization - The availability of this attitude is necessary for earth-looking experiments, and may be the preferred mode for zero-g experiments.

- Inertial Stabilization - The availability of this attitude is necessary for astronomy and other out-looking experiments.

- On-orbit Time of Two to Four Weeks - A large amount of research can be accomplished in less time, but the shuttle potential is severely compromised, especially in the biological sciences, if more than one week on orbit is not possible. I assume that a minimum of two days, and possibly as many as four to five, will be consumed with space-adaptation, unstowage, equipment check-out and calibration, and stowage for reentry. Such operational overhead has a major impact on a seven-day mission.

The main area requiring longer on-orbit time is that of biological experimentation. Some examples are:

- Sprout seeds at zero-g, then follow their growth in a centrifuge at various g levels.

- Use radioactive tracers to study biosystems after zero-g adaptation.

- Study processes requiring complete equilibration, such as: calcium turnover; water and hormone balance; dietary requirements; accumulation of toxins.

- Study slow nervous system changes, such as sleep requirements and gravity sensor adaptation.



- Study biorhythms, which require several days to change, and then more than a week to accumulate meaningful statistics.

- Any analyses of higher species, such as birds or mammals, require weeks.

In addition to biology, several astronomical time scales are longer than a week: solar rotation is about one month; the mean period of variable stars is about two weeks. Some crystal growth experiments may also require more than one week.

- Launch to a Variety of Orbits - An important aspect of the Shuttle's operational flexibility is the ability to launch to a variety of orbits (different inclinations, altitudes, eccentricities, nodes). A continuum of possibilities is not required, but the software should be provided for a large variety.

- On-orbit Maneuvering and Orientation - Considerable flexibility is needed here. Attitude changes will be necessary for astronomical observations. Experiments requiring very small g forces for long periods will need to have the Shuttle fly around them, compensating for drag forces. Minor orbit changes may be required for some earth-looking research.

- General Purpose Airlocks - For utility, economy and safety, the Shuttle sortie module should provide several general purpose airlocks of about 3/4-meter aperture. The investigator who wants to deploy an instrument in the space vacuum need only have an in-vacuum interface if an airlock "can" is provided, along with a deployment mechanism (and stabilized platform, when required). This aperture is large enough to deploy half-meter optical telescopes, to eject sounding rocket payloads, and to deploy other useful apparatus.

- Access to Center of Gravity by Experimenters - Very low accelerations ($\sim 10^{-4}$ to 10^{-5} g) are required for some experiments in materials science and in bioscience. Such low accelerations are possible only at the Shuttle CG. This will not be possible if the sortie module is protruding from the Shuttle.



Other important considerations are:

- Control Moment Gyro Stabilization - Some sensitive experiments may require CMG's in lieu of thrusters (e.g., astronomy, to avoid contamination, and materials science, to provide minimum acceleration and "dead band" displacements). It should be possible to place CMG's in the sortie module, at the expense of payload, when required.

- Crew Size of Seven to Ten - The sortie module should nominally provide facilities for seven to ten researchers. In many cases, an experiment, or engineering test, would be done by a team of 2 (or even 3) researchers, to maximize on-board "knowhow". The Shuttle is more effectively used if it can house several different investigations at the same time.* Certainly, the Shuttle must compete favorably with sounding rockets in more than just observing time. (That is, if a Shuttle launch costs \$5M, then it must be weighed against the fact that \$5M will fund at least 10 different sounding rocket research teams.)

- Sub-satellite Launch and Retrieval - Although it will not be a major sortie-mode operation, it would be useful to be able to deploy small sub-satellites (e.g., sounding rocket payloads) through the airlocks. If it is feasible, retrieval could provide for reduced cost of experimental apparatus.

IV. FUTURE GROWTH

The sortie mode module envisioned in this discussion utilizes the entire payload bay. Airlock "cans" protrude into the work area. The living area accommodates up to 10 scientists or engineers. This "general purpose" module would be useful for a large variety of space research and development for decades. In astronomy, for example, the useful research that can be done with a modest half-meter telescope, will never be exhausted. The planned 3-meter space telescope should be used only for research which requires its great resolving and light-gathering power.

*One "team" can certainly perform more than one "experiment". For example, a team of three biologists might operate several different biological experiments.



Figure 1 shows how the sortie module concept might grow. A 2/3 length general purpose module could be combined with a dedicated, special purpose module. A variety of these are shown:

- An airlock module, whose whole top opens to expose a larger (e.g., 1-meter) telescope or large cosmic ray experiment, or to deploy a large sub-satellite.
- A laboratory module, which would be completely outfitted as a bioscience facility or as a physics or materials science facility.
- An institutional module, which might belong to such organizations as NRL, NIH, ESSA, ESRO.
- A free-flying module, which is manned when in the payload bay, then deployed for retrieval/manning on a later flight. This would be particularly useful for biology experiments and engineering development tests, where long, unmanned periods would be desirable.

V. SUMMARY

I have tried to express a point of view about the Space Shuttle sortie operation which might be representative of the opinions of an outside science or engineering advisor.

The attempt has been to point out the potential of the sortie mode to break away from traditional space research dogma (both manned and unmanned) and pattern its approach more nearly like the NASA airborne research programs.

The key to this new way of doing space research is ability of the Space Shuttle to support

- A research crew consisting of scientists, engineers, and technicians;
- The flight of inexpensive, not necessarily highly reliable experiments, with minimal red tape and delays;
- Flexible operation, provided through a number of operational and hardware constraints which are designed into the Shuttle.



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It is crucial that the Space Shuttle be designed at this time in a manner that will insure that future options and flexibility are not compromised.

DB Wood
D. B. Wood

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Attachment
Figure 1

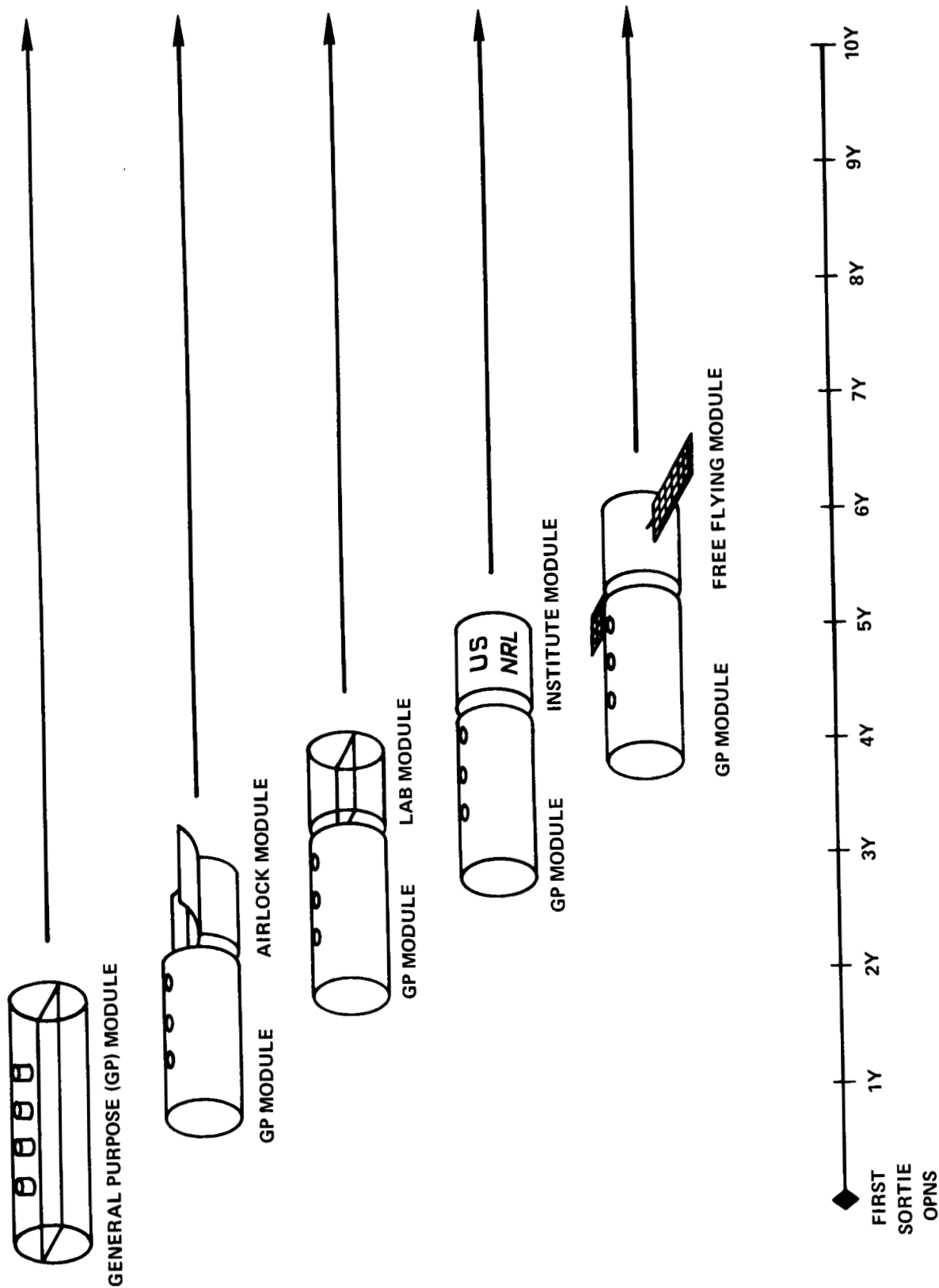


FIGURE 1 - SHUTTLE SORTIE GROWTH



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